Reference: *Biol. Bull.*, **137**: 250–255. (October, 1969)

THE PREZOEAL STAGE OF THE DUNGENESS CRAB, *CANCER MAGISTER* DANA[1]

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There is controversy in the literature as to the normalcy of the occurrence of a free prezoeal stage in the life history of the Dungeness crab, *Cancer magister*. MacKay (1942) stated that the eggs hatched into protozoeae (=prezoeae), but others reported that zoeae normally emerged from eggs and that free prezoeae were abnormal and died (Mir, 1961) or resulted from premature hatching of eggs (Poole, 1966). Our preliminary observations on egg hatching and on subsequent molting of prezoeae supported MacKay's belief. Before we could begin studies on the effects of the insecticide Sevin on survival and growth of *C. magister* larvae we had to resolve the controversy. This paper reports the results of a study undertaken to determine if salinity (1) affects egg hatching, (2) determines the type of larva that emerges from the egg, and (3) affects development of these larvae.

Materials and Methods

Ovigerous crabs caught in the ocean off the Oregon coast were held in the laboratory in flowing sea water for 3 days. One crab was then transferred to a 31-gallon tank containing filtered, sterilized, standing sea water of 30‰ at 11° C and it was held for an additional 3 days. Eggs began to hatch at the end of this time. We could predict from previous experience that eggs would hatch within a few days when egg coloration changed from a light to a dark brown. When hatching began, about 2000 eggs of normal appearance with all cuticular layers and ovigerous setae intact were gently removed in small bunches from the crab and held for 3 hours in filtered, sterilized sea water of 32‰ salinity at 10.5° C. Only a few eggs hatched during this time and the larvae, some of which may have hatched prematurely because of the recent egg handling, were discarded. At the end of the 3 hours, unhatched eggs still attached to ovigerous setae and with their cuticular layers intact were then selected at random and separated into 14 groups of 20 and each group was placed into a 250 ml beaker containing sea water at 10.5° C and of one of the following salinities: 10, 15, 20, 25, 30, and 32‰. A temperature-salinity combination of 17.5° C and 32‰ was also tested. Duplicate vessels were used for each test. The larvae, upon hatching, were immediately transferred to another beaker containing sea water of the salinity and temperature at which they had hatched. All vessels were held under constant light. Eggs were

[1] Technical Paper No. 2645, Oregon Agricultural Experiment Station. This study was supported by Public Health Service research grant CC 00303, from the National Communicable Disease Center, Atlanta, Georgia.

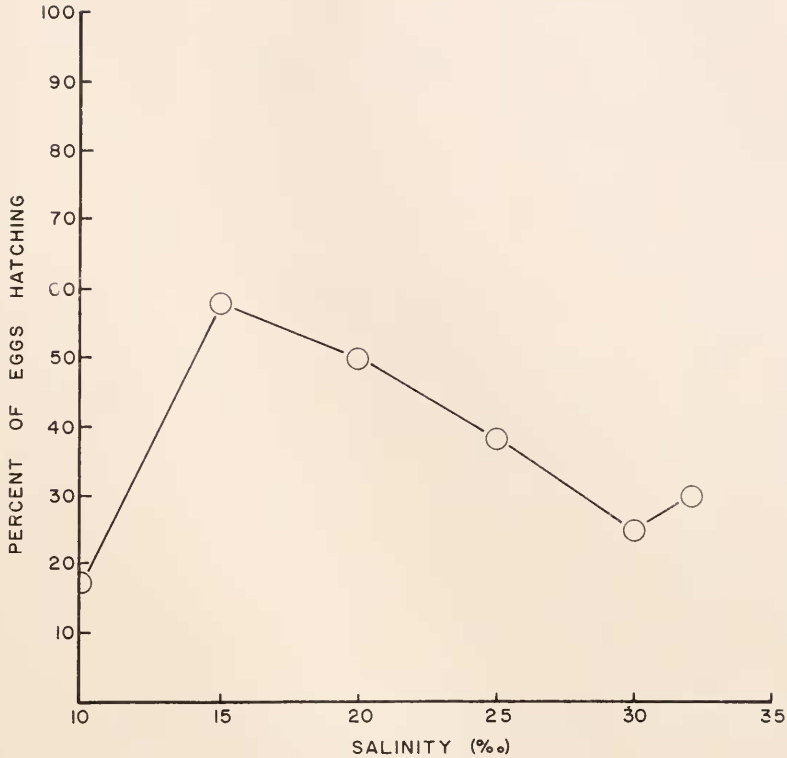

FIGURE 1. Effect of salinity on hatching of *Cancer magister* eggs at 10.5° C.

examined for hatching at intervals of about 5 minutes for 36 hours, and the hatched larvae were observed for molting at the same intervals for the first hour after they had hatched and then again at the end of the 36-hour experiment.

RESULTS

Some eggs hatched at all the test salinities, and 94% of these are known to have hatched into prezoeae (Table I). Of the remainder (6%), all of the eggs but one were in the two highest salinities at which the prezoeae may molt to zoeae as early as 2 minutes after hatching. Therefore, we believe that all of the hatching eggs hatched into prezoeae, but because of the short duration of this larval stage, especially at the higher salinities, some prezoeae could have hatched and molted between observations and thus they would not have been seen. The percentage of eggs hatching at 10.5° C increased as salinity decreased to an optimum of 15‰, but at 10‰ was lowest (Fig. 1). At a salinity of 32‰, the mean percentages of eggs that hatched at 10.5 and 17.5° C were 30 and 73%, respectively, indicating a marked temperature effect (Table I).

The mean percentages of prezoeae that molted to zoeae increased with increasing salinity from 0% at 10‰ to 100% at 30 and 32‰ (Table I and Fig. 2). With

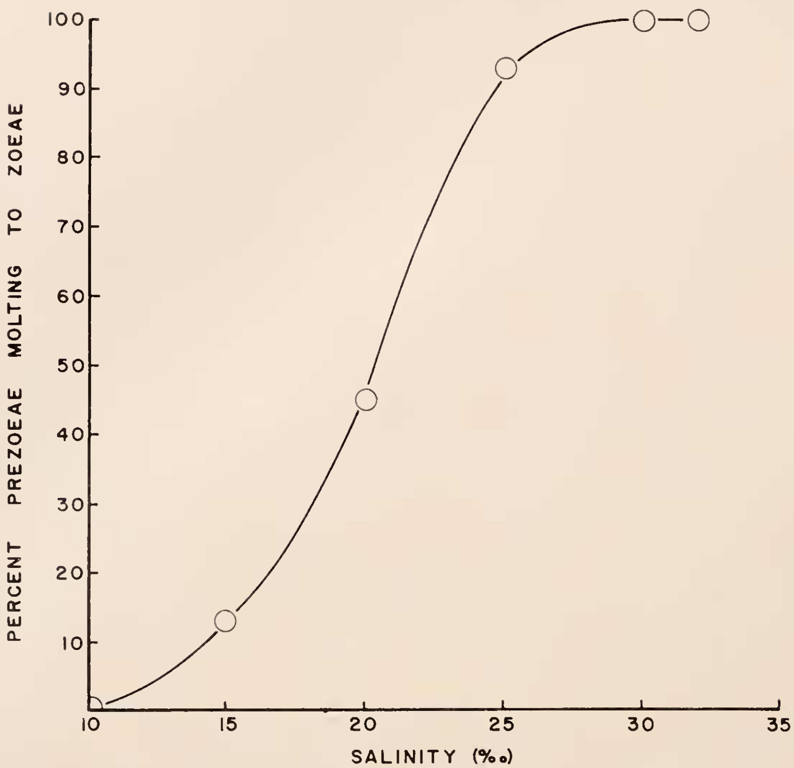

FIGURE 2. Effect of salinity on molting of *Cancer magister* prezoeae to zoeae.

increase of salinity from 15 to 32‰, the mean duration of the prezoeal stage decreased from more than 60 minutes to 11 minutes (Table I). At 32‰ salinity, all prezoeae molted to zoeae at the two test temperatures, and there was no effect of temperature on duration of the prezoeal stage.

Our morphological observations of the prezoeae agree with those of MacKay (1934) except that we did not see the lateral spines on the cephalo-thorax. The prezoeae have large eyes, a five-segmented abdomen, and a forked telson with spines (Fig. 3). They lack the rostral and dorsal spines of the zoeae. A further distinguishing characteristic, not mentioned by MacKay (1934), is the shortness of the natatory hairs on the maxillipeds. These hairs on the maxillipeds of the zoeae are much longer.

Prezoeae swam erratically, using their abdomen and telson for propulsion. As first noted by MacKay (1942) their movement resembled that of a mosquito larva. It was weak at the intermediate salinities and at 10 and 15‰ salinity the prezoeae did not swim.

Molting of prezoeae to zoeae required only a few seconds. The prezoeae first settled to the bottom of the container; then they extended the maxillipeds, the cuticle split, and the dorsal and rostral spines emerged. Our first-stage zoeae conformed morphologically with those described by Mir (1961) and Poole (1966).

TABLE I

Effects of salinity and temperature on hatching of Cancer magister *eggs and on molting of the prezoeae to zoeae**

Salinity (‰)	Hatched eggs		Free prezoeal stage confirmed		Duration of prezoeal stage (min)**		Prezoeae molted to zoeae	
	No.	%	No.	%	Mean	Range	No.	%
10	4	20	4	100	—	—	0	0
10	3	15	3	100	—	—	0	0
15	12	60	12	100	>60	—	1	8
15	11	55	11	100	>60	—	2	18
20	9	45	8	89	>44	13–>60	3	36
20	11	55	11	100	>25	9–>60	6	54
25	8	40	8	100	14	7–31	8	100
25	7	35	7	100	14	7–27	6	86
30	6	30	4	67	10	7–14	4	100
30	4	20	3	75	4	2–7	3	100
32	4	20	4	100	12	9–18	4	100
32	8	40	7	88	10	6–16	7	100
32†	17	85	15	88	11	3–35	15	100
32†	12	60	12	100	11	4–30	12	100

* Twenty eggs were used in each test and they were observed for hatching approximately every 5 minutes for 36 hours. All tests were done at 10.5° C unless noted otherwise.

** Hatched prezoeae were observed for molting approximately every 5 minutes for the first hour after they had hatched and again at the end of the 36-hour experiment.

† Test temperature was 17.5° C.

Five zoeae, which had developed from prezoeae, were randomly selected at the end of the experiment and held in sea water of 32‰ at 10° C for 3 days. All of them survived and appeared normal during this time.

DISCUSSION

Our observations support the contention of MacKay (1934) that the free prezoea is a normal stage in the life history of *C. magister* and not the abnormality that it was believed to be by Mir (1961) and Poole (1966). The results of our study support the statement of MacKay (1942) that the prezoeal stage is of short duration. This short duration may explain Poole's (1966) failure to see prezoeae, his observations having been made apparently no more frequently than once a day. Mir (1961), who also apparently observed his eggs no more frequently than once daily, stated that prezoeae, when present, were "imperfect" and died. He saw prezoeae apparently only when eggs were refrigrated or contaminated with protozoa and undoubtedly for these reasons his prezoeae were indeed abnormal and died without molting.

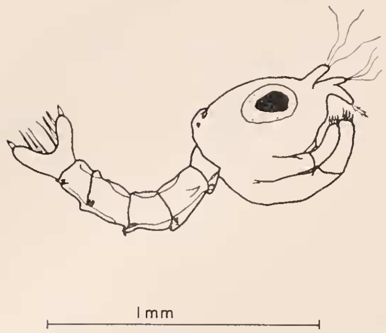

FIGURE 3. Prezoea of *Cancer magister* after hatching from the egg.

Churchill (1942), on the basis of laboratory studies, stated that a free prezoeal stage, which lasted from 30 to 60 minutes, was normal in the life history of the blue crab, *Callinectes sapidus*. However, Sandoz and Rogers (1944) believed that their experimental data did not support Churchill's statement. They concluded that unfavorable environmental conditions, such as suboptimal salinities, were responsible for the occurrence of free prezoeae, because in their experiments the numbers of free prezoeae increased as salinities decreased. They found no prezoeae when eggs were hatched at salinities ranging from 23.4 to 32‰, but at a salinity of 10‰, 90 to 100% of the hatched larvae remained as prezoeae. We found the same for *C. magister* prezoeae at low salinities, but at high salinities all of our prezoeae molted to zoeae. Sandoz and Rogers (1944) observed their eggs only twice daily, and therefore they could have failed to see the short-lived prezoeae at the higher salinities. The data of Sandoz and Rogers (1944), therefore, do not refute the belief of Churchill (1942), and for the same reason neither do the data of Costlow and Bookhout (1959), who also reported that eggs of *C. sapidus* at salinities ranging from 20.1 to 32‰ always hatched as first-stage zoeae. Costlow and Bookhout (1960) observed the eggs of six species of Brachyura, including *C. sapidus,* once daily and reported that most of the eggs of all species hatched as zoeae. Knudsen (1959) and Williams (1968) found that eggs of the crabs *Paraxanthias taylori* and *Carcinus maenas,* respectively, normally hatched as prezoeae, and the latter author reported that the average duration of the prezoeal stage of *C. maenas* was 4 to 5 minutes. It is clear, therefore, that the early life history of the blue crab and of other crabs in which the normal occurrence of a free prezoeal stage is doubted must be restudied.

The range of salinity that proved optimal for molting of our prezoeae was between 25.0 and 32‰ at 10.5° C; at 32‰ salinity, prezoeae molted equally well at 10.5 and 17.5° C. Reed (1969) found that the optimal salinities and temperatures for development in the laboratory of *C. magister* first-stage zoeae to the megalops stage were between 25 and 30‰ and between 10.0 and 13.9° C.

We wish to thank Mr. Paul H. Reed, Fish Commission of Oregon, for suggesting to us the possibility that free prezoeae are normal in the life history of *C. magister,* and Mr. Dennis E. Anderson and Mr. Nelson E. Stewart, Oregon State University, for making some of the observations.

Summary

1. Ninety-four per cent of eggs of the Dungeness crab, *Cancer magister*, held in sea water at 10.5 or 17.5° C and at salinities of 10 to 32‰ hatched into prezoeae during a 36-hour observation period. The highest and lowest numbers of eggs hatched at salinities of 15 and 10‰, respectively. At a salinity of 32‰, the mean percentages of eggs that hatched at 10.5 and 17.5° C were 30 and 73%, respectively.

2. With increase of salinity, the percentages of prezoeae that molted to first-stage zoeae increased from 0% at 10‰ to 100% at 30 and 32‰.

3. With increase of salinity from 15 to 32‰, the mean duration of the prezoeal stage decreased from more than 60 minutes to 11 minutes.

4. The experimental results show that the occurrence of a free prezoeal stage of short duration is normal in the life history of *C. magister*. The possibility that this is true for other Brachyura is discussed.

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